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PROTECT FROZEN FOODS
from
TEMPERATURE DAMAGE

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Despite the great commercial success of frozen foods, they face a constant danger—as well as an opportunity. That danger is exposure to high temperature. The opportunity is preservation of a still greater portion of original quality by rigid avoidance of all temperature damage. To help the many thousands who handle frozen foods, here are facts on kinds of quality loss—and their rates at various temperatures—from a comprehensive current project called Time-Temperature Tolerance of Frozen Foods.

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

The Time-Temperature-Tolerance Project

Several years ago industrial leaders proposed research that would be commensurate with the needs of the rapidly growing frozen-foods industry.

New features of the investigation were to be complete coverage of the commercial life of frozen foods, use of commercial samples from major production areas over several seasons, and exposure to the temperature hazards that exist in the distribution system.

A major objective is facts on changes in quality that can be translated into improved protection in the manufacture, transport, storage, and wholesale and retail selling of frozen foods. Other aims are better tests for losses of quality and better knowledge of what each segment of the industry must do to protect maximal quality for consumers.

The project was undertaken by the Western Utilization Research and Development Division, Agricultural Research Service, United States Department of Agriculture. Products included are fruits, concentrated orange juice, vegetables, poultry, and prepared frozen foods.

This report summarizes results obtained thus far--presented in relation to the problems of temperature control in commercial operations. Technical reports are available to those who request them.

Prepared originally for a frozen-food-industry convention in September, 1957; revised for additional conventions in February, 1958. For additional information write to Western Regional Research Laboratory, Albany 10, Calif., headquarters of the Wetsern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

Protecting Frozen Foods from Temperature Damage

Quality and Temperature

The frozen-food industries have established high standards and new concepts of quality, which are important in merchandising. They are basic reasons for consumers' purchases--the real reasons for the success of frozen foods.

Quality is complex. It includes color, flavor, texture, attractive appearance, nutritive values. In the Time-Temperature-Tolerance Project and other frozen-food research, chemical analyses are used for vitamins and other compounds, light-measuring colorimeters and spectrophotometers for color, force-measuring instruments for tenderness, trained human tasters for flavor and appearance. Such methods supply reliable measurements.

A familiar and useful example of quality and its decline is supplied by fresh foods--and freshly prepared foods. They age quickly in ordinary surroundings--lose color, flavor, texture, nutritive values--even before they spoil from action of bacteria and molds. This loss of prime quality can be simply described as aging. Essentially the same changes occur in frozen foods if temperature is not low enough.

An erroneous assumption is this: That a cold and hard package of frozen food is adequately protected against loss of prime quality. All the chemical reactions that result in loss of quality accelerate as temperatures rise from 0°F. or lower level. At 15° these changes occur several times as fast as at 0°--and at 25° to 30° several times as fast as at 15°F., but most products are hard at 20°-25°F. and lower.

Another erroneous assumption is this: That lowering temperature down to zero or lower corrects temperature damage. As temperature of frozen foods rises or falls, losses of top quality move fast or slowly. They never move in reverse. No one can make old foods young again.

Temperature damage is retained indefinitely. Even slight changes in color, flavor, or other quality factors early in the commercial life of a frozen food remain regardless of excellent handling later.

Important general facts: Decline from topmost quality proceeds by numerous processes whose initial stages are not detectable on casual examination. These changes are barely active at zero or lower but as temperature rises their rates increase rapidly--doubling several times in the range up to 25°F. Severe damage results from accumulations of mild damage, as well as from single severe exposures.

TEMPERATURE DAMAGE IN FROZEN FOODS

Frozen Fruits

Frozen fruits are damaged in several ways, and certain types of damage become conspicuous early. Changes in color and appearance are important and easily detected. Less easily detected changes also occur at the same time.

Examples are dark-brown peach slices, discolored strawberries, raspberries with color bled into the sirup, dull-brown cherries with toughened skins. Quality changes may begin even before freezing and develop a little at a time with minor mishandlings--or they may occur with brief severe exposure.

Of four retail-packed fruits investigated comprehensively, frozen peaches are most quickly and conspicuously damaged. Brown slices can cause consumer complaint, and they may become apparent after total exposures of 1 to 2 days or less time at 30°, 2 weeks at 20°, 2 to 3 months at 10°, or 2 years or longer at 0°F.

Strawberries undergo flavor changes that become easily detectable within totals of 1 to 2 days at 30°, 6 to 12 days at 20°, or about 3 months at 10°--but will lose little top quality in well over a year at steady 0°F. The discoloration and loss of vitamin C develop simultaneously. Flavor change is early evidence of quality loss.

Frozen raspberries reveal temperature damage less quickly than other fruits but tend to lose color from berries to sirup at fairly rapid rates. This change is not accompanied by drastic change in flavor but definitely indicates that the product is losing its fresh condition. Zero or lower supplies protection.

Fruits contain important amounts of vitamin C (ascorbic acid). Top-quality strawberries contain more than orange juice. Frozen peaches are frequently packed with added ascorbic acid to retard browning. Temperature abuse causes loss of this vitamin--and rate of loss is related to rates of other losses of quality factors.

The project has shown that previous adverse temperature experience can be detected by objective tests. The test for ascorbic acid is useful, particularly for strawberries. Extent of flow of color from berries to sirup is also a reliable indicator. Movement of soluble solids (sugars) from sirup to fruit occurs only in the thawed state, and thus equal distribution of solids indicates previous thawing.

Those who handle frozen fruits, and also other products, may well remember this fact: Held a day at 20° F., products may not show damage--for example, peaches may not turn brown. The next handler, however, may expose the product to minor temperature hazards and find that the damage is conspicuous, and it can't be corrected.

Frozen Concentrated Orange Juice

Several factors are especially significant in the handling of frozen concentrated orange juice. It is a major outlet for the nation's orange crop and a major product in the frozen food industry. It is widely consumed for its vitamin C (ascorbic acid) and other nutritive values. Its color, flavor, and the stability of its cloud are quality factors to which millions of consumers are highly sensitive.

The sealed metal containers protect against access of air and thus limit oxidative reactions, but they also allow thawing that would seriously damage most other containers. The product may seem to be adequately protected, when actually it is undergoing changes that cause consumers to regard it as a low-grade rather than a high-grade product.

Tendency to develop instability of cloud (that is, to separate when mixed with water) has led to an industry-wide practice of mild heating in the processing of this product. This practice has improved stability but temperature damage remains as a major problem. Tendency to lose stability of cloud was observed in all samples, but in varying degrees at temperatures above 0° F. Over long periods at 0° the products gradually lose ability to withstand temperature damage.

In the project some but not all heat-treated samples retained stable cloud in an initial test of 5 days at 10° followed by a steady rise to 40° with immediate refreezing to 0° F. All unheated samples failed in this single test. All the heat-treated samples that survived the first test failed in a second similar test later.

In the lower range of exposures for longer times, most unheated samples were able to retain cloud when exposures over a year added up to no more than 24 days at 10° F. Heated samples generally withstood mistreatment twice as severe, but varied. Thus temperature damage accumulates and quickly exhausts the original stability of frozen concentrated orange juice.

Undesirable change in flavor was found to be a slower process than cloud loss, and loss of vitamin C much slower. These losses, however, do proceed faster as temperature rises and eventually add severely to the total quality losses in frozen concentrated orange juice.

Frozen Vegetables

Temperature-tolerance studies on vegetables are incomplete but present data supply general descriptions of quality loss and measurements of rates. Temperature-damaged green snap beans, for example, first darken and later turn olive drab and eventually brown. Peas turn grayish-green and then yellowish as green color is lost.

Trained judging panels are consistently able to detect a color change in beans held at 0°F. in about 4 months. They can do the same with peas at 0°F. in about 6 months. These observations indicate the comparative rates of color change in these two products. They do not evaluate the severity of damage; at zero steadily held, overall quality continues at a high level for at least 2 years.

The trained panel identifies the same change mentioned above in beans held at 10° after one month, after 10 days at 20°, and after about 3 days at 30°F. For peas the time periods are roughly double in each case.

Undesirable change in flavor of beans is detectable by the trained panel after 3 to 4 times the periods required for detections of color change at the various temperatures listed above. Flavor change in peas is slightly more rapid. Thus for both vegetables, color changes more rapidly than flavor.

Losses of chlorophyll (green pigment) and vitamin C are useful measures of loss of quality. In effectively blanched green beans, chlorophyll is lost at the rate of about 10% per year at 0°F., which is not severe. At 10°, however, this rate triples. At 20° it is 16 times and at 30°F. 60 times as fast as at 0°F. Improperly blanched beans will lose color even faster. Rates of loss of vitamin C are similar.

The facts above emphasize the striking increases in rates as temperatures rise higher and higher above zero--and particularly as they reach temperature levels of 25°, 30°, and above. Long periods at lower temperature above 0°F.--without apparent softening--will result in the same sort of damage.

Frozen Poultry Products

Quality losses in frozen ready-to-cook poultry arise from moisture loss, rancidification, and darkening. Rate of deterioration approximately doubles for each 10 degrees (F.) of rise in temperature. Turkeys are less stable than chickens, and cut-up poultry is less stable than whole birds.

Lowering temperature lessens moisture loss, which causes unattractive appearance. Poorly packaged cut-up chicken fryers lost 1.1% moisture in 4 months at 10°F. but only 0.2% at -10°F. This loss is reduced also by moisture-proof packaging. Package failure arises from rough handling, poor material, or failure to seal effectively.

Rancidity is also reduced by lowering temperature and use of less permeable packaging materials. Products that develop rancid off flavor within 1 month at 20°F. are stable for 3 months at 10°F., 6 months at 0°F., and 10 months at -10°F.

Two other temperature-sensitive changes are frost formation in the package and darkening of skin. Frosting can occur in a moisture-proof package and is increased by widely fluctuating temperatures. Darkening takes place when frozen turkeys are allowed to stand at 10° to 25°F. for short periods in distribution and retailing. Low steady temperature (0°.F.) will minimize or prevent both of these changes.

For average commercial frozen poultry products in relatively moisture- and air-proof packages, 0°F. maintains optimum quality for a year and provides a margin of safety for most distribution schedules.

Prepared Frozen Foods

Products studied thus far are fried chicken, turkey dinners and pies, creamed chicken and turkey products, and sauces and gravies used in such products as a la king and custard and pudding desserts.

The flavor change first detected in cooked poultry meat is loss of "freshly cooked" flavor, which is followed eventually by staleness and finally by distinct rancidity. At 20°F. flavor changes are detectable in fried chicken within less than 2 weeks, staleness or rancidity develops within 6 weeks to 3 months, and mold occurs on pies held 9 months. At 10°F. and lower, stability of flavor is greatly affected by exposure of the meat to air. For example, the sauce or gravy in pies protects the meat, and hence dinners, pies, creamed products and a la king are protected against serious flavor damage for as long as 6 to 12 months at 10°F. or lower. Fried chicken, however, suffers damage twice as quickly at these temperatures.

Curdling, separation of liquid, and loss of smoothness are undesirable changes that can develop in puddings, desserts and gravies after they are thawed. Such foods become much more defective in this respect when exposed to temperatures above 0°F. Research has revealed improvement from use of certain thickening agents (such as waxy rice flour) and stabilizers, but even improved products are sensitive to temperature damage.

MEASURING TEMPERATURES

Improved temperature protection means more excellent quality delivered from farms and freezing plants to consumers. Every industrial group bears a heavy responsibility. Each must guard against creeping, accumulating damage just as effectively as against sudden damage.

Improved handling means constant attention to product temperatures. Control of product temperatures in turn means measurements of temperature consistently, in the products themselves and in their environments. Frequent temperature measurement enables one to become "temperature minded" and to understand equipment performance as well as quality losses that develop in products.

As an aid to greater and more effective use of thermometers the Time-Temperature-Tolerance Project has included a study of product temperature measurement in cases of frozen foods without destruction of either carton or individual packages. The method simplifies the operation, reduces time required, and produces accurate results.

A metal, disk-type thermometer is used. With a razor knife a small opening is made in the carton wall to reveal where the corner package comes together with the next one. The thermometer stem is simply inserted about 3 inches in contact with both packages. The cut end of the carton opening is forced against the stem. About 5 minutes are required to obtain a reading that closely approximates that of the center of the product.

Temperature in the center of the carton can be taken similarly, and if it is higher than the corner temperature it is likely that the carton has been exposed to higher temperature recently. More detailed information is available on this study, and also on the entire project.

Thermometer readings are important. They measure not only degrees of protection but also rates at which quality is disappearing.

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